Patent claims

1. An optically pumped radiation-emitting semiconductor device having a semiconductor body which includes at least one pump radiation source (20) and a surface-emitting quantum well structure (11), the pump radiation source (20) and the quantum well structure (11) being in monolithically integrated form, and the pump radiation source (20) generating pump radiation (2) for optically pumping the quantum well structure (11), characterized in that a recess (10) for introducing the pump radiation (2) into the quantum well structure (11) is formed in the semiconductor body between the pump radiation source (20) and the quantum well structure (11).

2. The semiconductor device as claimed in claim 1, characterized in that the recess (10) is in trench form and runs obliquely or perpendicular with respect to a direction of propagation of the pump radiation (2).

3. The semiconductor device as claimed in claim 1 or 2, characterized in that the recess (10) has a first side face (26) facing the pump radiation source (20) and an opposite, second side face (27) facing the quantum well structure (11), the pump radiation (2) entering the recess (10) through the first side face (26) and then entering the quantum well structure (11) through the second side face (27).

4. The semiconductor device as claimed in claim 3, characterized in that the second side face (27) is parallel to the first side face (26).

5. The semiconductor device as claimed in claim 3 or 4, characterized in that the first and/or the second side face (26, 27) includes an angle equal to the Brewster angle with a direction of propagation of the pump radiation (2), in particular with a main direction

of emission of the pump radiation source (20).

6. The semiconductor device as claimed in one of claims 1 to 5, characterized in that the recess (10) is filled with a dielectric or a semiconductor material.

7. The semiconductor device as claimed in claim 6, characterized in that the recess (10) is filled with a material which has a refractive index substantially equal to the refractive index of the pump radiation source (2), the refractive index of the quantum well structure (11) or the geometric mean of the latter two refractive indices.

8. The semiconductor device as claimed in one of claims 1 to 7, characterized in that the semiconductor device comprises a vertical emitter with a radiation-generating region formed by the quantum well structure (11).

9. The semiconductor device as claimed in claim 8, characterized in that the vertical emitter is a vertically emitting laser, in particular a VCSEL or a disc laser.

10. The semiconductor device as claimed in one of claims 1 to 9, characterized in that the pump radiation source (20) is a pump laser.

11. The semiconductor device as claimed in claim 10, characterized in that the pump laser is an edge-emitting laser.

12. The semiconductor device as claimed in claim 10 or 11, characterized in that the pump laser is a ring laser.

13. The semiconductor device as claimed in one of

claims 10 to 12, characterized in that the pump laser has a resonator, and the quantum well structure (11) is arranged within the resonator.

14. The semiconductor device as claimed in one of claims 1 to 13, characterized in that the pump radiation (2) is introduced into the quantum well structure (11) in the lateral direction.

15. The semiconductor device as claimed in one of claims 1 to 14, characterized in that the pump radiation source (20) and the surface-emitting quantum well structure (11) are formed from different semiconductor layer sequences.

16. The semiconductor device as claimed in one of claims 1 to 15, characterized in that the pump radiation source (20) and the surface-emitting quantum well structure (11) are formed epitaxially and in succession.

17. The semiconductor device as claimed in one of claims 1 to 16, characterized in that the recess (10) is arranged in a grow-in region between the pump radiation source (20) and the surface-emitting quantum well structure (11).

18. The semiconductor device as claimed in one of claims 1 to 17, characterized in that the pump radiation source (20) has at least one waveguide layer (23, 24).

19. A method for fabricating an optically pumped semiconductor device having a semiconductor body which includes a surface-emitting quantum well structure (11) and at least one pump radiation source (20) which generates pump radiation (2) for optically pumping the quantum well structure (11), the pump radiation source

(2) and the quantum well structure (11) being monolithically integrated, comprising the steps of:

a) providing a substrate (1),

b) epitaxially growing a plurality of semiconductor layers on to the substrate (1), which layers include the quantum well structure (11),

c) partially removing the semiconductor layers, and

d) epitaxially growing the pump radiation source (20) in the region uncovered by the removal in step c) so that the pump radiation source (20) adjoins the quantum well structure (11),

characterized in that

a recess (10) for introducing the pump radiation (2) into the quantum well structure (11) is formed between the pump radiation source (20) and the quantum well structure (11).

20. The method as claimed in claim 19, characterized in that in step d) semiconductor layers are grown in order to form the pump radiation source (20), these layers in a grow-in region (19), at least partially growing together in the lateral direction with the quantum well structure (11), and the recess (10) is formed by at least partial removal of the grow-in region (19).

21. The method as claimed in claim 19 or 20, characterized in that the recess (10) is formed by etching, in particular, wet-chemical or dry-chemical etching.

22. The method as claimed in one of claims 19 to 21, characterized in that the recess (10) is designed in trench form, in particular as an etched trench.

23. The method as claimed in one of claims 19 to 22, characterized in that the recess (10) is filled with a material which transmits the pump radiation.

24. The method as claimed in claim 23, characterized in that the recess (10) is filled with silicone or a semiconductor material.

25. A method for fabricating an optically pumped semiconductor device having a semiconductor body which includes a surface-emitting quantum well structure (11) and at least one pump radiation source (20) which generates pump radiation (2) for optically pumping the quantum well structure (11), the pump radiation source (2) and the quantum well structure (11) being monolithically integrated, comprising the steps of:

a) providing a substrate (1),

b) epitaxially growing a plurality of semiconductor layers on to the substrate (1), which layers include the pump radiation source (20) and form the quantum well structure (11),

c) forming a window in the plurality of semiconductor layers for the quantum well structure (11), and

d) epitaxially growing the quantum well structure (11) in the window so that the pump radiation source (20) adjoins the quantum well structure (11),

characterized in that

a recess (10) for introducing the pump radiation (2) into the quantum well structure (11) is formed between the pump radiation source (20) and the quantum well structure (11).

26. The method as claimed in claim 25, characterized in that in step d) semiconductor layers are grown in order to form the quantum well structure (11), these layers in a grow-in region, at least partially growing together in the lateral direction with the layer sequence of the pump radiation source (20), and the recess (10) is formed by at least partial removal of the grow-in region (19).

27. The method as claimed in claim 25 or 26, characterized in that the recess (10) is formed by etching, in particular, wet-chemical or dry-chemical etching.

28. The method as claimed in one of claims 25 to 27, characterized in that the recess (10) is designed in the form of a trench, in particular as an etched trench.

29. The method as claimed in one of claims 25 to 28, characterized in that the recess (10) is filled with a material which transmits the pump radiation.

30. The method as claimed in claim 29, characterized in that the recess (10) is filled with silicone or a semiconductor material.